TECHNICAL REPORT
70-12-FL

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PARAMETERS FOR MOISTURE CONTENT FOR STABILIZATION OF FOOD PRODUCTS (PHASE II)

By

Frank Hollis, Milton Kaplow,

Joseph Halik, Harold Nordstrom

General Foods Corporation

White Plains, New York

Contract No: DAAG17-67-C-0098

August 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

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FOREWORD

As noted in the report (FL-77) covering the first phase of this investigation, the effectiveness of the combat soldier must be maintained under all foreseeable circumstances. The soldier required to carry his food supply while on prolonged missions must be assured acceptable, nutritious and safe foods which can be consumed under conditions likely to be encountered. In designing a food supply for such a mission, special emphasis is directed toward minimizing weight, bulk and packaging material and for assuring consumption without preparation or diversion of attention. On the basis of both theory and current applications, intermediate moisture foods offer an attractive potential for meeting these vigorous requirements.

The experimental program under Phase I demonstrated that a great variety of familiar foods could be preserved at water activities depressed to around 0.75 by the incorporation of solute, primarily glycerol and a small amount of potassium sorbate as an antimycotic. Foods so preserved were rated acceptable although inferior in flavor to their familiar counterparts. This level of acceptability was retained after storage for 4 months at 38° C. No objections were noted in relation to odor, texture, color or appearance. In contrast to freeze-dried foods, none of the intermediate moisture items gave the oral sensation of dryness. This investigation seeks to extend the technology of intermediate moisture foods to multicomponent items, primarily of the casserole-type, to improve upon flavor, and to provide an insight into bacteriological safety and nutritional losses.

This investigation was performed at the Technical Center of the General Foods Corporation in Tarrytown, New York. The experimental program was conducted under the general supervision

of Mr. Frank Hollis and Mr. Milton Kaplow. Mr. Joseph Halik served as Principal Investigator and Mr. Harold Nordstrom was his collaborator. This study was funded under the project titled: "Food Processing and Preservation Techniques" (Project Number 1M624101D553) through contract DAAG 17-67-C-0098, "Parameters for Moisture Content for Stabilization of Food Products." Project Officer for the Food Laboratory, U.S. Army Natick Laboratories was Dr. Maxwell C. Brockmann. Mr. Justin M. Tuomy, also of the Food Laboratory, served as Alternate Project Officer.

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ABSTRACT

Utilizing the immersion-equilibration procedure developed during the previous investigation of this program, Phase I, the following casserole-type products were prepared by combining, in accordance with standard formulations, the respective components, including the sauce, which were separately processed to a water activity between 0.80 and 0.85: chicken a la King, ham in cream sauce, tuna in cream sauce, Hungarian goulash, Irish stew, sweet and sour pork and macaroni and cheese. In addition two items, apple pie filling and beef stew, which failed to pass the storage test of Phase I were reformulated to conform. All named items were rated acceptable after 4 months storage at 38° C. except the ham in cream sauce which was found to be rancid.

Samples of chicken a la King and ham in cream sauce were inoculated with Staph. aureus, E. coli, Salmonella, and Cl. perfringens at levels of 6-14,000 organisms per gram. Except for S. aureus viable counts were uniformly less than 10 per gram after one month storage at 38° C. After four months samples inoculated with S. aureus ran 0.4 organism per gram. Observations were performed on the loss of thiamine, riboflavin and niacin during storage for 4 months at 38° C. Thiamine losses amounted to 40-60 percent, niacin around 20 percent, while no loss was observed for riboflavin. Notwithstanding substantial improvements over Phase I in acceptability of all items and components thereof, the depression of water activity as accomplished in Phase II results in a less acceptable flavor.

Statement of the Problem

The objective of Phase II of this project was to extend to casserole items procedures developed in Phase I[1] for preparing a variety of potential ration components with a reduced moisture range corresponding to water activities from 0.75 to 0.90 that would assure wholesomeness and preserve essential physical, chemical, nutritional and sensory characteristics during storage. The following products were to be investigated:

a. Chicken a la King
b. Ham in cream sauce
c. Tuna in cream sauce
d. Hungarian goulash
e. Irish stew
f. Ham and sweet potato casserole
g. Improved beef stew
h. Improved apple pie filling

A modification in the list of items was made because of a rancidity type spoilage encountered in the ham in cream sauce during storage. Two other casserole items were substituted for the two items containing ham. These items are:

macaroni and cheese
sweet and sour pork

In addition, ham in cream sauce casserole was to be investigated further and modified.

The specifications included the requirements that approved additives could be used to modify water activity and to control adverse changes incident to storage, and also that each food would be treated with an FDA approved antimycotic to suppress mold development.

A specific objective of Phase II was to conduct an inoculation study on samples using common food pathogens followed by tests for recovery after suitable storage.

Also, to determine nutritional quality, data to be obtained were on vitamin content changes in various foods processed and stored at intermediate moisture levels.

As in Phase I, approximately 500 grams of each product would be supplied to the Project Officer upon completion of Phase II of the project.

Background

"Intermediate moisture" foods can be defined as foods that are partially dehydrated and have a suitable concentration of dissolved solids to bind the remaining water sufficiently to inhibit the growth of bacteria and yeast. Depending upon the concentration of dissolved solids, mold growth is inhibited with or without the use of antimycotic agent(s). Such foods are not new. The pemmican of the American Indians was a form of "intermediate moisture" food, and dried fruits, sweetened condensed milk and fruit preserves are more common examples. However, these are specialized foods, and until recently the "intermediate moisture" category was limited to a few such specialized foods. Lately there has been the development of what is called "soft, moist pet food" (2,3). This product is made by mixing wet and dry ingredients with suitable soluble solids and antimycotics to obtain a product that is moist enough to be eaten without rehydration and yet is resistant to microbiological spoilage. The parameters of moisture content, antimycotics and soluble solids have been studied quite extensively, (4) and there is considerable technology available on this type of "intermediate moisture" food. This technology has been limited to fabricated products formed from comminuted ingredients. In the items required for both Phase I and II of this project, the natural structure and texture of the fresh material was required, and therefore the "soft, moist" technology could not be applied directly. However, the principles related to preservation and food quality could be applied. In Phase I of this project, infusion procedures were developed for preparing a variety of food items. Two general procedures were used to adjust foods to intermediate moisture levels: infiltration of dehydrated, usually freeze-dried, food with aqueous solutions and a soak procedure with or without a combined cooking in which the raw food of normal moisture content was equilibrated in a more concentrated solution to yield the desired Aw.

Approach to the Problem

In Phase I, intermediate moisture food preparation was found to be feasible by two methods. The first was infusion of dried material with sufficient water and water-binding agents to give a food that was microbiologically stable, and the second was infusion of full moisture material to obtain the same result. When starting with pre-dried food pieces, it was found that freeze-dried material was best. The second method based on "soak-equilibration" avoided a predrying processing step and was considered to be the most promising of the two methods uncovered. The "soak-equilibration" method was extended into the preparation of all the casserole type items for Phase II. The water activities of the Phase II items were increased to the 0.82-0.86 range from the predominantly 0.75 range of the Phase I items in an attempt to improve product eating quality without risking microbiological spoilage. This in effect resulted usually in increased water and reduced glycerol levels in the items.

In Phase I, 2.0% propylene glycol and 0.3% potassium sorbate were used in most of the products to prevent spoilage. In Phase II, the propylene glycol was eliminated from most items resulting in flavor improvement without spoilage occurrence.

Experimental Procedures and Results

The "soak-equilibration" method was utilized in the preparation of all the casserole items for Phase II. This process consists of soaking full moisture raw or pre-cooked food pieces in equilibration solutions so that after draining, the moisture content and the water activity have been reduced to the desired levels to make the food pieces edible as is or rehydrated and to maintain them microbiologically stable at room temperature. Raw food pieces for the cassrole items were cooked in the equilibration solution. "Target" formulas for the food items were calculated using Raoult's equation for effect of soluble solids on water activity of solutions. The equilibration solution is based on the liquid phase composition in the target formula and includes adjustment for the water content in the starting full moisture food piece material. The food is immersed in the solution until the liquid phases in the food and the soak solution equilibrate.

The processing formula has been expressed by the mathematical relationship:

$$C = \frac{W_S \, C_S}{W_S + W_f}$$

where C = desired concentration of non-aqueous solutes in equilibrated solution
C_S = initial concentration of non-aqueous solutes in external (infusing) solution
W_S = initial weight of above
W_f = initial weight of water in food

Glycerol continues to be the most promising additive to date serving the dual purpose of binding water to reduce activity and to impart moist appearance and texture to the intermediate moisture food. Glycerol levels in the meats for Phase II were generally up to 20.0% and in the vegetables for Phase II generally up to 30.0%. Salt and flavorings were added where p ssible primarily to reduce or mask the sweet, bitter, glycerol tastes.

For all the items, cook book recipes were referred to for common ingredients and ratios. Formulations were developed separately for sauces and food piece components. Cooking of the food pieces was done mainly by immersion in the equilibration solutions and heating to approximately 99° C. for 10-15 minutes. The usual procedure was to soak the food pieces for 15-20 hours in the same equilibration solution and drain. Drained food pieces were then used as ingredients without any further processing. For quality control, water activity measurements (5) were made on all intermediate moisture components in addition to a water activity measurement (6) on the completed casserole. Either Cenco moisture determinations or vacuum-oven moisture analyses (7) were conducted on all intermediate moisture components and casseroles. The overall moisture contents for the completed casserole items were in the 34.-44.0% range.

I. Specific Item Formulation and Method of Preparation Follow

A. Chicken A La King

Formulations were developed separately for chicken pieces, mushroom slices, pimiento and pepper pieces and sauce as follows:

1. Chicken Pieces

Fresh raw chicken breast pieces (½-1" cubes) were cooked at 95-98° C. for 15 minutes in an equilibration solution containing the proper amount of additives to produce the desired moisture content and water activity. After cooking, the chicken was soaked overnight under refrigeration in the same liquid, reheated and drained. The resulting intermediate moisture chicken was substantially improved over that described in Phase I due to increased water activity (Aw=0.84 instead of 0.73) reduced level of additives and elimination of propylene glycol. Ingredients used and finished IM product measurements are shown in Table I.

2. Mushroom Slices

Canned mushrooms were sliced (1/8" thick) and soaked for approximately 48 hours under refrigeration in an equilibration solution and then drained. The resulting intermediate moisture mushroom slices had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are shown in Table II.

3. Pimiento Pieces

Canned roasted pimientos were cut into pieces (¼" squares) and soaked for about 48 hours under refrigeration in an equilibration solution and drained. The resulting intermediate moisture pimiento pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are shown in Table III.

4. Pepper Pieces

Fresh green peppers were cut into pieces (½" squares), blenched by immersion in boiling water for 15 seconds, quenched in ice water for 20 seconds, soaked approximately 48 hours under refrigeration in an equilibration solution and then drained. The resulting intermediate moisture pepper pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are shown in Table IV.

5. A La King Sauce

An intermediate moisture a la King sauce was formulated. The addition of egg yolk for emulsification of the oil, water, fat system worked very well. Development of a stable emulsion for intermediate moisture sauces or gravies was successful. Earlier intermediate moisture gravy emulsions as in the intermediate moisture beef stew had poor stability in storage. A blend of oil and fat (Dri-Fri) was determined based on fairly constant fluidity when evaluated at temperatures in the 0-38° C. range. When water is added during recipe preparation (optional) the sauce has a more opaque, creamier appearance. In preparing the sauce, water and glycerol were first mixed and then blended with a premix of all dry ingredients. Using a Waring Blendor approximately three quarters of this mixture was blended with the egg yolk followed by gradual addition of Myverol (melted) and the remaining portion of the mix. Formulation and finished IM product measurements are shown in Table V.

6. Complete Chicken A La King Casserole

The chicken a la King casserole was prepared by adding the various intermediate moisture components in ratios so that the completed casserole appeared similar to a control based on Durkee's

a la King mix prepared by the package recipe. All components with the exception of pimiento were prepared without propylene glycol to improve flavor and with approximately the same water activities in order to prevent changes in quality during storage due to water activity equilibration. The complete intermediate moisture formula #6003-70 for chicken a la King casserole follows:

Ingredients	Formula #	%	Aw	% Moisture (Cenco)
A la King Sauce	6003-64	53.80	0.86	20.0
Chicken Pieces	6003-71	41.00	0.84	42.6
Mushroom Slices	5944-83	2.60	0.82	46.8
Pimiento Pieces	6003-47	1.34	0.85	43.4
Pepper Pieces	6003-52	1.26	0.82	42.0
		100.00		

Casserole Moisture (Cenco) = 31.2%
Casserole Aw = 0.85

B. Ham In Cream Sauce

A formulation was developed which underwent a rancidity type spoilage in storage.

As a result a new formulation was developed. Ham modifications in the second formulation included substitution of cured, smoked ham (Smithfield) for canned (Unox) ham and addition of erythorbic acid to Tenox 6 for increased antioxidant protection. Formulations for the second ham in cream sauce follow:

1. Ham Slices

Smoked Smithfield ham was trimmed and sliced (pieces approximately 1/8" x ½" x 3/4") and cooked at 95-98° C. for 10 minutes in an equilibration solution and soaked overnight under refrigeration in the same equilibration solution and drained. The resulting intermediate moisture ham had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table VI.

2. Cream Sauce

An intermediate moisture sauce was formulated. The sauce is basically the same as that for chicken a la King with the exception of myverol omission. The blending procedure used was similar to that for the a la King sauce. Formulation and finished IM sauce measurements are in Table VII.

3. Complete Ham in Cream Sauce Casserole

The second complete ham in cream sauce casserole was prepared by blending the intermediate moisture components at a sauce-meat ratio similar to that of the chicken a la King casserole. The formula (#6068-43) for the complete intermedidate moisture ham in cream sauce casserole follows:

Ingredients	Formula #	%	Aw	% Moisture (Vacuum-Oven)
Cream Sauce	6068-42	60.0	0.84	19.0
Ham Slices	6068-44	40.0	0.85	40.1
		100.0		

Casserole Moisture (V-O) = 27.4%
Casserole Aw = 0.85

C. Tuna in Cream Sauce

Formulations were developed separately for tuna pieces, peas, carrot dices, mushroom slices and cream sauce as follows:

1. Tuna Pieces

Canned white Tuna Albacore packed in water was drained and cut into ½-1" cube dimensions and soaked for about 24 hours under refrigeration in an equilibration solution and drained. The resulting intermediate moisture tuna had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table VIII.

2. Peas

Frozen peas were thawed and cooked at 95-98° C. for 10 minutes in an equilibration solution, soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture peas had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table IX.

3. Carrot Dices

Frozen carrot dices (3/8") were thawed and cooked at 95-98° C. for 15 minutes in an equilibration solution, soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture carrot dices had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table X.

4. Mushroom Slices

Canned, sliced mushrooms (approximately 1/8" thick) were soaked for about 36 hours under refrigeration in an equilibration solution and drained. The resulting intermediate moisture mushroom slices had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XI.

5. Cream Sauce

The sauce has the same composition as that used in the ham in cream sauce casserole. The formula for the cream sauce can be found in Table VII.

6. Complete Tuna in Cream Sauce Casserole

The formula for the complete intermediate moisture casserole (#5713-98) follows:

Ingredients	Formula #	%	Aw	% Moisture (Vacuum-Oven)
Sauce	6068-06	49.3	0.83	19.7
Tuna	6068-07	37.8	0.81	38.8
Peas	6068-05	6.8	0.83	50.2
Carrots	6068-04	3.7	0.81	51.5
Mushrooms	5713-100	2.4	0.83	51.4
		100.0		

Casserole Moisture (V-O) = 34.3%
Casserole Aw = 0.84

D. Hungarian Goulash

Formulations were developed separately for egg noodles, beef pieces, onion pieces and sauce as follows:

1. Egg Noodles

Egg noodles were cooked for 5 minutes in boiling water and drained, then cooked at 95-98° C. for 4 minutes in an equilibration solution and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture noodles had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XII.

2. Beef Pieces

Raw trimmed chuck beef pieces (½-1" cubes) were cooked at 95-98°C. for 15 minutes and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture beef pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XIII.

3. Onion Pieces

Raw onion slices (1/8" thick) were cut into segments (1-1½" long, ¼" wide) and soaked overnight in an equilibration solution under refrigeration and drained. The resulting intermediate moisture onion pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XIV.

4. Sauce

A sauce was formulated using the basic system of the cream sauce with modifications for color and flavor. Preparation was similar to that for cream sauce as reported on page 8 of this report. The color was pre-dissolved in the water, glycerol phase. The tomato flavor was pre-blended with the Wesson Oil and Dri-Fri ingredients. After completion, sauce was heated to 85° C. to thicken and stabilize. Formulation and finished IM product measurements are in Table XV.

5. Complete Hungarian Goulash Casserole

The Hungarian Goulash casserole was prepared by adding the various intermediate moisture components in ratios so that the combination appeared similar to S.S. Pierce's canned beef goulash with noodles. The formula for the complete intermediate moisture casserole (#6068-14) follows:

Ingredients	Formula #	%	Aw	% Moisture (Vacuum-Oven)
Egg Noodles	5965-95	36.0	0.84	48.0
Sauce	6068-35	31.0	0.84	28.2
Beef	6068-22	25.0	0.82	44.5
Onion	6068-15	8.0	0.85	58.5
		100.0		

Casserole Moisture (V-O) = 36.5%
Casserole Aw = 0.84

E. Irish Stew

Formulations were developed separately for lamb pieces, potato slices, small whole onions, carrot dices, peas and gravy as follows:

1. Lamb Pieces

Raw trimmed leg of lamb pieces (½-1" cubes) were cooked at 95-98° C. for 17 minutes and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture lamb pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XVI.

2. Potato Slices

Raw potato slices (½" x 1" x 1") were cooked at 95-98° C. for 18 minutes and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture potato slices had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XVII.

3. Onions

Frozen, small, whole onions were thawed and cooked in an infusion solution at 95-98° C. for 8 minutes and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture onions had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XVIII.

4. Carrot Dices and Peas

The intermediate moisture carrot dices and peas formulations for the Irish stew casserole storage evaluation are the same as those prepared for the tuna in cream sauce casserole and can be found in Tables IX and X .

5. Gravy

A gravy was formulated using the basic system of the cream sauce with modifications for color and flavor. Preparation was similar to that for cream sauce as reported on page 8 of this report. The lamb aroma was pre-blended with the Wesson Oil and Dri-Fri ingredients. After completion, gravy was heated to 85° C. to thicken and stabilize. Formulation and finished IM product measurements are in Table XIX.

6. Complete Irish Stew Casserole

The Irish stew casserole was prepared by adding the various intermediate moisture components in ratios so that the combination appeared similar to S.S. Pierce's canned lamb stew. The formula for the complete intermediate moisture casserole (#6068-23) follows:

Ingredients	Formula #	%	Aw	% Moisture (V-O)
Gravy	6068-38	41.0	0.85	25.7
Lamb	6068-26	18.0	0.86	40.2
Potatoes	6068-25	18.0	0.87	53.1
Onion	6068-24	9.0	0.85	59.8
Carrots	6068-04	7.0	0.81	51.5
Peas	6068-05	7.0	0.83	50.2
		100.0		

Casserole Moisture (V-O) = 40.4%
Casserole Aw = 0.86

F. Improved Beef Stew

The improvement of the Phase II beef stew over the Phase I beef stew was mainly in improving the emulsion stability of the gravy phase. The addition of egg yolk for emulsification of the oil, water, fat system was found to add stability to the system. In the Phase I work, the beef stew gravy emulsion was unstable at 38° C. In addition, improvement in taste resulted from increased water activity (0.78 for Phase I, 0.82 for Phase II) and elimination of propylene glycol.

Formulations were developed separately for potato slices, beef pieces, carrot dices, peas and gravy as follows:

1. Potato Slices

Raw potato slices (1/8" x ½" x 3/4") were cooked at 95-98° C. for 15 minutes and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture potato slices had acceptable eating qualities and water activity. The flavor was improved by the addition of beef soup base in the equilibration solution. Ingredients used and finished IM product measurements are in Table XX.

2. Beef Pieces

Raw trimmed chuck beef pieces (½-1" cubes) were cooked at 95-98° C. for 15 minutes and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture beef pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XXI.

3. Carrot Dices and Peas

The intermediate moisture carrot dices and peas formulations for the beef stew storage evaluation are the same as those prepared for the tuna in cream sauce casserole and can be found in Tables IX and X.

4. Gravy

A gravy was formulated using the basic system of the cream sauce with modifications for color and flavor. Preparation was similar to that for cream sauce as reported on page 8 of this report. Formulation and finished IM product measurements are in Table XXII.

5. Complete Improved Beef Stew Casserole

Beef stew casserole (#5713-97) was prepared by adding the various intermediate moisture components in the following ratios:

Ingredients	Formula #	%	Aw	% Moisture (V-O)
Gravy	6068-01	44.5	0.82	29.3
Potato	6068-03	22.2	0.84	49.6
Beef	6068-02	16.7	0.83	42.3
Carrots	6068-04	8.3	0.81	51.5
Peas	6068-05	8.3	0.83	50.2
		100.0		

Complete Casserole Moisture (V-O) =34.9%
Complete Casserole Aw = 0.82

G. Improved Apple Pie Filling

The improvement of the Phase II apple pie filling over the Phase I apple pie filling was the elimination of browning at 38° C. storage. This in effect was accomplished by (1) blanching the apple slices in 0.1% ascorbic acid solution for 5 minutes at 85°C. prior to further treatment and (2) eliminating contact of intermediate moisture apples with a flavor, spice matrix containing dextrose while in storage.

Formulations were developed separately for the apple slices and dry filling mix as follows:

1. Apple Slices

Fresh Cortland apples were sliced, blanched in 0.1% ascorbic acid solution for 5 minutes at 85°C., quenched in ice water for 5 minutes, drained, soaked 48 hours under refrigeration in an equilibration solution and drained. The resulting intermediate moisture apple slices had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XXIII.

2. Dry Filling Mix

A dry filling mix was formulated for taste, appearance, and consistency for compatibility with the intermediate moisture apple slices and the recipe. The formulation for this filling mix can be found in Table XXIV.

3. Complete Improved Apple Pie Filling

The composition of the complete improved apple pie filling follows. The recipe can be found in Part II of this section, page 18.

Ingredients	Formula #	%	Aw	Grams*
Apples	6068-12	55.5	0.85	500
Dry Filling Mix	6068-40	18.5	----	166
Water (Recipe Added)		26.0	----	234
		100.0		900

H. Macaroni and Cheese

Formulations were developed separately for the two components as follows:

*For one 9 inch pie

1. Macaroni

Elbow macaroni were cooked for 8 minutes in boiling water and drained, then cooked at 95-98°C. for 8 minutes in an equilibration solution and soaked overnight under refrigeration in the same liquid and drained. The resulting intermediate moisture elbow macaroni had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XXV.

2. Cheese

A cheddar-American cheese flavored intermediate moisture formulation was developed and can be found in Table XXVI. The method of preparation follows:

(a) Blend water and glycerol in a Waring type blendor. Add a pre-blend of starch, salt, beef soup base, Kelcoloid, MSG, potassium sorbate, citric acid and mustard powder.

(b) Blend together and heat cheeses, cheese flavoring, Hydrol 100, non-fat dry milk solids, Dri-Fri, Wesson Oil and lecithin.

(c) Add glycerol mixture to cheese mixture and heat to 77°C. (water bath) with stirring.

(d) Blend mix in Waring type blendor until smooth, about 1-2 minutes.

3. Complete Macaroni and Cheese

The ratio of macaroni to cheese and the finished IM product measurements follow:

Formula #6068-08 for Complete Macaroni and Cheese Casserole

Ingredients	Formula #	%	Aw	% Moisture (V-O)
Macaroni	6068-09	65.0	0.83	46.1
Cheese	6068-10	35.0	0.82	23.0
		100.0		

The composite moisture and Aw were not determined because macaroni and cheese were packaged separately. The recipe can be found in Part II of this section, page 18 .

I. Sweet and Sour Pork

Formulations were developed separately for pork pieces, carrot dices, pineapple pieces, celery pieces and sauce as follows:

1. Pork Pieces

Raw trimmed loin pork pieces (½-1" cubes) were cooked at 95-98°C. for 15 minutes and soaked overnight under refrigeration in the same liquid, reheated and drained. The resulting intermediate moisture pork pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XXVII.

2. Carrot Dices

The intermediate moisture carrot dice formulation for the sweet and sour pork is the same as that prepared for the tuna in cream sauce casserole and can be found in Table X.

3. Pineapple Pieces

Canned pineapple chunks were drained and soaked 48 hours under refrigeration in an equilibration solution and drained. The resulting intermediate moisture pineapple pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XXVIII.

4. Celery Pieces

Raw celery stalks were sliced into ¼" cross sections, blanched in boiling water for 15 seconds, quenched in ice water and soaked overnight under refrigeration in an equilibration solution and drained. The resulting intermediate moisture celery pieces had acceptable eating qualities and water activity. Ingredients used and finished IM product measurements are in Table XXIX.

5. Sauce

A sweet and sour sauce was formulated based on a recipe found to have satisfactory eating qualities. Glycerol was substituted for part of the water to lower the water activity. Formulation and calculated overall moisture and water activity can be found in Table XXX. A water activity measurement could not be determined by the hygrosensor because of acetic acid contamination. The preparation used is as follows. The potassium sorbate was dissolved in the water, followed by the glycerol and sodium chloride. A premix of all the other ingredients except the catsup and vinegar was then blended with the water phase and heated to 98°C. for 8 minutes. Catsup and vinegar were then well blended into the sauce mixture for completion.

6. Complete Sweet and Sour Pork Casserole

Sweet and sour pork (#6068-29) was prepared by adding the various intermediate moisture components in the following ratios:

Ingredients	Formula #	%	Aw	% Moisture (V-O)
Pork	6068-31	42.5	0.81	41.2
Sauce	6068-32	42.5	0.85*	34.9
Carrots	6068-04	6.0	0.81	51.5
Pineapple	6068-33	6.0	0.85	43.0
Celery	6068-34	3.0	0.83	39.6
		100.0		

Complete Moisture (V-O) = 44.1%
Complete Aw (calculated)= 0.83

II. Recipe Preparation For Eating

With the exception of the improved apple pie filling and macaroni and cheese, all casserole items can be used as is or with water added. By adding approximately 50-250 grams water to one kilogram of casserole and heating, the consistency of the sauce is optimized.

*Aw for sauce was calculated

The apple pie filling is prepared by soaking the apple pieces in excess water for approximately ten minutes, draining and combining with the sugar, starch, spice mix and water in a pie shell and baking for approximately 1/2 hour at 218°C.

The macaroni and cheese casserole is prepared by soaking the macaroni pieces in excess hot water for approximately ten minutes, draining and combining with the intermediate moisture cheese. For one kilogram of macaroni and cheese, 150 grams of water are added and the total mixture is blended and heated to melt the cheese.

III. Storage for Microbiological, Sensory and Gross Stability Evaluation

All nine intermediate moisture products investigated under Phase II were filled into size 211 x 400 tinplate cans and sealed under nitrogen for storage and stored at 0°C. and 38°C.

For the macaroni and cheese casserole, the cheese component was heat sealed under nitrogen in polyethylene pouches. One pouch and a proportional amount of macaroni were filled into each 211 x 400 tinplate can and sealed under nitrogen.

The apple slices for the apple pie filling were canned under nitrogen. The sugar, starch, spice mix was packaged separately in heat sealed Mylar/polyethylene/foil/polyethylene pouches.

A. Microbiological Stability

Initial counts and counts after one month and four months storage (at 38°C) for bacteria, mold and yeast are shown in Table XXXI. The methods employed to evaluate microbiological viability are given in the Appendix.

From the data in Table XXXI, it can be concluded that all nine items were resistant to the growth of bacteria. Molds and yeast were not detected.

B. Gross Examination

1. Chicken a la King #6003-70

Meat slightly redder color, sauce slightly thicker at 38°C.

2. Ham in Cream Sauce #6003-72-3

A rancidity type spoilage at 38°C.

3. Improved Ham in Cream Sauce #6068-43

Sauce thicker at 38°C. No rancidity type spoilage as in previous formula.

4. Tuna in Cream Sauce #5713-98

Peas slightly darker and sauce slightly thicker at 38°C.

5. Hungarian Goulash #6068-14

Color change in sauce from orange to yellow, noodles tenderer and tomato flavor stronger at 38°C.

6. Irish Stew #6068-23

Peas and carrots slightly browner, meat slightly redder and tenderer, sauce slightly thicker at 38°C.

7. Improved Beef Stew #5713-97

No emulsion separation as in phase I formula. Peas slightly brown at 38°C.

8. Improved Apple Pie Filling #6068-12

Apple slices slightly yellower at 38°C.

9. Macaroni and Cheese #6068-08

Macaroni tenderer and cheese moderately browner at 38°C.

10. Sweet and Sour Pork #6068-29

Meat slightly tenderer at 38°C.

C. Sensory Evaluation

Sensory evaluation was conducted to compare differences in flavor and texture between the intermediate moisture items stored at 0°C. and 38°C. and commercial products (grocery store canned items or freshly prepared full moisture items). Intermediate moisture samples were evaluated "as is" or with added water.

The procedure was to have a panel of four judges, trained in and experienced with the flavor and texture evaluations of food products, evaluate the intermediate moisture items on a 10-point rating scale of difference. The commercial products were considered as controls and assigned a 10 rating. The panel compared the 0°C. and 38°C. samples "as is" or with added water to the commercial product controls to determine the relative difference among the samples within each product type. In addition to the difference in ratings, flavor, texture and mouthfeel characteristics were described.

The sensory evaluation ratings for all items are summarized in Table XXXII. All the stored samples of the intermediate moisture items received scores of 5 or better.

Relative differences among samples within each product type follow:

1. Chicken A La King

A fresh, full moisture control was prepared using Durkee's a la King mix and recipe with freshly boiled diced white chicken meat added.

The sample stored at 0°C. was rated 6.9 and described as bitter, sweet, low in meat flavor and slightly tough and chewy. The sample stored at 38°C. was rated 5.1 and described similarly with meat being more tough and chewy and having an old meat aromatic.

2. Improved Ham in Cream Sauce

A fresh full moisture control was prepared using Durkee's white sauce mix and recipe with fresh boiled cured smoked ham.

The sample stored at 0°C. was rated 8.9 and described as low meat flavor, sweet, bitter. The sample stored at 38°C. was rated 6.6 and described similarly with meat being dry.

3. Tuna in Cream Sauce

A fresh full moisture control was prepared using Durkee's white sauce mix and recipe with canned peas, diced carrots and sliced mushrooms.

The sample stored at 0°C. was rated 8.0 and described as low total aromatics, sweet and bitter. The sample stored at 38°C. was rated 7.1 and described similarly with tuna and vegetables being dry.

4. Hungarian Goulash

Grocery canned S.S. Pierce beef goulash with noodles was used as the control.

The sample stored at 0°C. was rated 7.6 and described as high onion, sweet and bitter, low meat flavor. The sample stored at 38°C. was rated 6.4 and described similarly and as having an old meat flavor.

5. Irish Stew

Grocery canned S.S. Pierce lamb stew was used as the control.

The sample stored at 0°C. was rated 8.9 and described as sweet, bitter, low meat flavor. The sample stored at 38°C. was rated 7.0 and described similarly with very low aromatics.

6. Improved Beef Stew

Grocery canned Dinty Moore's beef stew was used as the control.

The samples stored at 0°C. were rated 6.7 and described as sweet, bitter, high spice, low meat and vegetable notes. The sample stored at 38°C. was rated 5.6 and described similarly and as having an old meat flavor.

7. Improved Apple Pie Filling

Grocery canned Comstock apple pie filling and Flako pie crust were used as the control.

The sample stored at 0°C. was rated 8.8 and described as high cinnamon, high sweet, low apple notes. The sample stored at 38°C. was rated 7.8 and described as high cinnamon, sweet, no apple notes.

8. Macaroni and Cheese

A fresh full moisture control was prepared using Velveeta American cheese and freshly cooked elbow macaroni.

The sample stored at 0°C. was rated 7.4 and described as sweet, bitter, low aromatics. The sample stored at 38°C. was rated 5.6 and described similarly with a musty cheese aromatic. Macaroni was described as soft in both samples.

9. Sweet and Sour Pork

A fresh full moisture control was prepared using same recipe as for the intermediate moisture item but without use of glycerol, salt and potassium sorbate.

The sample stored at 0°C. was rated 7.9 and described as low meat flavor, high sweet, low sour. The sample stored at 38°C. was rated 6.7 and described similarly and as having a low overcooked meat note.

IV. Inoculation with Pathogens Study

The chicken a la King and ham in cream sauce were considered to be representative of intermediate moisture food samples in systems with Aw's up to 0.86 with 0.3 percent potassium sorbate.

Both complete intermediate moisture casseroles were inoculated separately with Salmonella, E. coli, Staph. aureus and Cl. perfringens at a level of 10,000 organisms/gm by water spraying and Hobart mixing. A minimum of amount of water was used so that the water activity of the resulting product was essentially unchanged. Samples were packaged without further treatment, stored at 38°C. and analyzed in triplicate at storage intervals of zero time, 1 month and 4 months. Based on the resulting data in Table XXXIII, it can be concluded that intermediate moisture systems with Aw's up to 0.86 in combination with 0.3 percent potassium sorbate are very effective in inhibiting survival of pathogenic organisms such as those inoculated. Microbiology methods used for analyses can be found in the Appendix.

V. Nutritional Quality Study

Chicken a la King and ham in cream sauce casseroles and the apple slices for pie filling were packaged individually under air or nitrogen or both atmospheres (see Table XXXIV) in heat sealed Mylar/polyethylene/foil/polyethylene pouches and stored at 38°C. Zero time and four month analyses have been conducted on the two meat casseroles for niacin, thiamine and riboflavin and on the apple slices for ascorbic acid and thiamine. Riboflavin underwent no reduction in storage. Niacin showed a 20.0% loss, thiamine a 40-46.0% loss (meat casseroles) and ascorbic acid a 42.0% loss.

Analyses and methods referred to can be found in Table XXXIV.

For comparison [8] with other food preservation methods, frozen pork has a 40.0% thiamine loss after 6 months, canned pork a 48.0% thiamine loss after 43 weeks at 27-39°C. and a complete thiamine loss at 10 weeks for heat denatured pork whereas there is little or no niacin loss.

Frozen peaches show progressive losses of reduced ascorbic acid. At -17°C., losses of added ascorbic acid were about 30% and 50% with fluctuation from -20° to -15°C. for one year. The oxidation of ascorbic acid is a major change in composition of frozen fruits accompanying frozen storage. Information concerning the retention of thiamine in frozen fruits during storage under commercial conditions was not located.

In canned fruits, ascorbic acid and thiamine are affected by storage to the greatest extent of the nutrients. Commercially canned orange juice had a 60% ascorbic acid loss after 18 months storage at 37°C. and a 17% thiamine loss after 24 months storage at 27°C. Commercially canned peaches had a 19% thiamine loss after 12 months storage at 27°C.

The vitamin analysis study indicates that intermediate moisture processed foods have retentions during storage similar to those of foods processed by commercial methods.

Discussion

The "soak-equilibration" method developed in Phase I of this project was used extensively in the preparation of the Phase II items covered in this report. The project work continued to be exploratory with emphasis on preparing the nine food items rather than on perfecting the method and its parameters.

Enough water was used in the equilibration solutions to predissolve the additives in order to cause an osmotic pressure difference resulting in the infusion of additives into the moist food pieces. An excess solution of water and additives was used so that the food pieces were completely immersed.

Components were prepared individually in order to optimize the eating quality of each. Some foods for example could tolerate more salt and less glycerol than others. For some components there were special ingredients such as soup base for the chicken and beef pieces, antioxidants for the ham pieces and texture and color stabilizers for the apple slices. It is feasible that several or all components could be equilibrated concurrently in the same solution if their final target compositions are similar.

In some preparations, food pieces were blanched or precooked prior to soak-equilibration as was done for the mushroom slices, pimiento and pepper pieces in the chicken a la King. In other preparations, food pieces were cooked in the equilibration solution as was done for the lamb pieces, potato slices, small whole onions, carrot dices and peas in the Irish stew.

Heat applied to the food pieces/equilibration solution mixture as in cooking reduces the soak time for equilibration. When cooking was done in the solution, equilibration was complete within 24 hours whereas an extended soak closer to 48 hours was required for equilibration in a room temperature or refrigerated solution.

All soak-equilibrations were conducted under refrigeration as a precaution to reduce the risk of spoilage prior to equilibration. It is possible that refrigeration during equilibration could be eliminated especially when cooking is done in the solution.

The soak-equilibration method results in an excess solution which was separated after equilibration from the food pieces by draining. Condensing the excess solution for reuse appears to be feasible using either a reverse-osmosis or distillation process. In the work covered in this report, excess solutions were not reused.

It is probable that during soak-equilibration, some soluble solids (sugars, proteins, vitamins) are extracted from the food pieces. This might account for why browning was not more serious as in the intermediate moisture apple slices. Possibly with repeated use of the excess solution, the extraction of food soluble solids would be reduced because of higher extract solute concentration in the equilibration solution.

Product improvements of Phase I over Phase II were accomplished by modifying the ratio of the water and glycerol content for a higher water activity while retaining microbiological stability and also by eliminating propylene glycol as an ingredient. There is room for further improvement in quality of the products. A bland tasting glycerol substitute is needed.

Acceptability of the intermediate moisture items is increased by the addition of water or the replacement of additives with water as in a soak rinse recipe used for the macaroni in the pie filling. Warming products increases acceptability of items usually eaten warm or hot.

An inoculation study using pathogens was found to confirm the effectiveness of controlled water activity on microbiological stability.

Results of a vitamin analysis study indicate that intermediate moisture processed foods have retentions of vitamins during storage similar to those of foods processed by commercial methods.

Browning of the apple pie filling and separation of the gravy emulsion, two problems uncovered during storage in Phase I were corrected as reported in the Experimental Procedures and Results Section.

Conclusions and Recommendations

The following nine items were prepared as intermediate moisture items to meet the requirements of the contract. (a) chicken a la King; (b) ham in cream sauce; (c) tuna in cream sauce; (d) Hungarian goulash; (e) Irish stew; (f) improved beef stew; (g) improved apple pie filling; (h) macaroni and cheese and (i) sweet and sour pork.

The "soak-equilibration" method of distributing water activity lowering additives and controlling moisture uniformly throughout food pieces which was developed in Phase I was used to prepare the nine items.

Samples of the nine items were stored for four months at 38°C. On evaluation during and after storage, all items were found to be microbiologically stable under non-sterile conditions. Sensory evaluation of the stored samples showed them to be palatable. Browning of the apple product and gravy emulsion instability were corrected.

An inoculation study using pathogenic organisms showed that the intermediate moisture systems used in this study not only prevented the growth of pathogens but caused their reduction.

A vitamin analysis study indicates that intermediate moisture processed foods have retentions during storage similar to those of foods processed by commercial methods.

The overall quality of the nine items in terms of taste was somewhat sweet and bitter. It appears that a bland tasting glycerol substitute or a method of retaining microbiological stability with reduced levels of additives is necessary.

It is recommended that work be continued to optimize formulations and to improve quality, preferably choosing items that can be used to demonstrate the feasibility of intermediate moisture foods. Identification of compounds other than glycerol that could bind water and that would not contribute off flavors is very important to further development of IM foods. In addition more information is needed on measurement of water binding and the structure of water in these products.

Summary

The objective of this project (Phase II) was to extend to casserole items procedures developed in a previous investigation (Phase I) for preparing a variety of potential ration components with a reduced moisture range corresponding to water activities from 0.75 to 0.90 that would assure wholesomeness and preserve essential physical, chemical, nutritional and sensory characteristics during storage.

The following nine items were investigated:

a. chicken a la King

b. ham in cream sauce

c. tuna in cream sauce

d. Hungarian goulash

e. Irish stew

f. improved beef stew

g. improved apple pie filling

h. macaroni and cheese

i. sweet and sour pork

The"soak-equilibration" method (with or without combined cooking) developed in Phase I of this project was used extensively in the preparation of all of the items investigated.

Taste quality of the items was improved by adjusting the ratio of the water and glycerol content for a higher water activity and also by eliminating propylene glycol as an ingredient.

All the prepared items were stored for four months at 38°C. and examined. All items were microbiologically stable under non-sterile conditions, and required no commercial sterilization.

Browning of the apple pie filling and separation of the gravy emulsion, two problems uncovered during storage in Phase I were corrected.

The ham in cream sauce casserole was satisfactorily reformulated to correct a rancidity type spoilage that occurred in the first formulation during storage.

The samples (including the reformulated ham in cream sauce) were evaluated after storage by a sensory panel. All samples were rated acceptable.

Taste continues to be a technical problem. A bland tasting substitute for glycerol would be desirable. However, work should be continued on improving and optimizing selected intermediate moisture items.

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Citation of the above names does not constitute an official endorsement or approvel.

Table I

Formula #6003-71 For Chicken Pieces Prepared For Chicken A La King Storage Evaluation

Chicken, Raw, Trimmed White Meat	%	Grams
Solids	26.3	507.0
Moisture (Cenco)	73.7	1421.0
	100.0	1928.0

Equilibration Solution For Chicken Pieces

	%	Grams
Water	45.05	1735.2
Glycerol	39.70	1532.7
Good Season's Chicken Soup Base	10.10	395.2
Sodium Chloride	4.50	175.4
Potassium Sorbate	0.65	26.2
	100.00	3864.7

Moisture (Cenco) = 42.6%
Aw = 0.84

Table II

Formula #5944-83 For Mushroom Slices Prepared For Chicken A La King Storage Evaluation

Mushrooms, Canned, Drained	%	Grams
Solids	12.8	29.1
Moisture (Handbook)*	87.2	196.9
	100.0	226.0

Equilibration Solution For Mushroom Slices

	%	Grams
Glycerol	64.6	312.0
Water	31.7	153.0
Sodium Chloride	3.2	15.3
Potassium Sorbate	0.5	2.4
	100.0	482.7

Moisture (Cenco) = 46.8%
Aw = 0.83

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table III

Formula #6008-47 For Pimiento Pieces Prepared For Chicken A La King Storage Evaluation

Pimientos, Canned, Drained	%	Grams
Solids	7.6	25.4
Moisture (Handbook)*	92.4	308.6
	100.0	334.0

Equilibration Solution For Pimiento Pieces	%	Grams
Glycerol	66.6	423.0
Water	24.9	158.0
Sodium Chloride	4.8	30.2
Propylene Glycol	3.2	20.3
Potassium Sorbate	0.5	3.2
	100.0	634.7

Moisture (Cenco) = 43.4%
Aw = 0.85

Table IV

Formula #6003-52 For Pepper Pieces Prepared for Chicken A La King Storage Evaluation

Pepper, Fresh Green, Trimmed	%	Grams
Solids	6.8	45.6
Moisture (Handbook)*	93.2	627.4
	100.0	673.0

Equilibration Solution For Pepper Pieces	%	Grams
Glycerol	67.8	863.4
Water	25.7	327.9
Sodium Chloride	6.0	78.3
Potassium Sorbate	0.5	6.5
	100.0	1276.1

Moisture (Cenco) = 42.0%
Aw = 0.82

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8.

Table V

Formula #6003-64 For A La King Sauce Prepared For Chicken A La King Storage Evaluation

Ingredients	%
Wesson Oil	39.35
Water	14.10
Non-Fat Dry Milk Solids	12.75
Glycerol	11.75
Whole Egg Yolk (51.0% H_2O)	10.00
Dri-Fri (Durkee)	7.97
Frodex, 15 DE	2.00
Sodium Chloride	1.00
Myverol, type 18-30	.90
Potassium Sorbate	.30
	100.00

Moisture (Cenco) = 20.0%
Aw = 0.85

Table VI

Formula #6068-44 For Ham Prepared For Ham in Cream Sauce Storage Evaluation

Ham, Smoke Cured, Trimmed, Boiled	%	Grams
Solids	41.3	206.5
Moisture (Cenco)	58.7	293.5
	100.0	500.0

Equilibration Solution for Ham Slices	%	Grams
Water	52.673	504.000
Glycerol	39.190	375.000
Sodium Chloride	7.320	70.000
Potassium Sorbate	0.780	7.500
Tenox 6	0.031	0.296
Erythorbic Acid	0.006	0.057
	100.000	956.853

Moisture (v-o)* = 40.1%
Aw = 0.85

*vacuum-oven method

Table VII

Formula #6068-42 For Cream Sauce Prepared For Ham in Cream Sauce Casserole Storage Evaluation

Ingredients	%
Wesson Oil	39.35
Water	14.10
Non-Fat Dry Milk Solids	12.75
Glycerol	11.73
Fresh Egg Yolk	10.00
Dri-Fri with .076% Tenox 6 (Drew)	7.87
Frodex, 15 DE	2.90
Sodium Chloride	1.00
Potassium Sorbate	0.30
	100.00

Moisture (v-o) = 19.0%
Aw = 0.84

Table VIII

Formula #6068-07 For Tuna Prepared For Tuna in Cream Sauce Storage Evaluation

Tuna, Canned, Drained	%	Grams
Solids	40.0	1400.0
Moisture (Handbook)*	60.0	2100.0
	100.0	3500.0

Equilibration Solution For Tuna Chunks	%	Grams
Glycerol	53.6	3178.0
Water	38.6	2289.0
Sodium Chloride	7.1	420.0
Potassium Sorbate	0.7	42.0
	100.0	5929.0

Moisture (v-o) = 38.8%
Aw = 0.81

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table IX

Formula #6068-05 For Peas Prepared For Tuna In Cream Sauce
Storage Evaluation

Peas, Frozen, Thawed	%	Grams
Solids	19.3	386.0
Moisture (Handbook)*	80.7	1614.0
	100.0	2000.0

Equilibration Solution for Peas	%	Grams
Glycerol	49.2	2416.0
Water	45.4	2226.0
Sodium Chloride	4.9	240.0
Potassium Sorbate	0.5	24.0
	100.0	4906.0

Moisture (v-o) = 50.2%
Aw = 0.83

Table X

Formula #6068-04 For Carrots Prepared For Tuna in Cream Sauce
Storage Evaluation

Carrots, Diced, Frozen, Thawed	%	Grams
Solids	11.8	200.0
Moisture (Handbook)*	88.2	1500.0
	100.0	1700.0

Equilibration Solution For Carrot Dices	%	Grams
Glycerol	59.2	2115.0
Water	34.7	1241.0
Sodium Chloride	5.5	195.5
Potassium Sorbate	0.6	19.6
	100.0	3571.1

Moisture (v-o) = 51.5%
Aw = 0.81

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table XI

Formula #5713-100 For Mushrooms Prepared For Tuna In Cream Sauce Storage Evaluation

Mushroom Slices, Canned, Drained	%	Grams
Solids	12.8	59.4
Moisture (Handbook)*	87.2	404.6
	100.0	464.0

Equilibration Solution For Mushroom Slices	%	Grams
Glycerol	66.1	534.5
Water	29.2	236.6
Sodium Chloride	3.4	27.8
Potassium Phosphate	0.7	5.6
Potassium Sorbate	0.5	4.2
Citric Acid	0.1	1.4
	100.0	810.1

Moisture (v-o) = 51.4%
Aw = 0.83

Table XII

Formula #5965-95 For Egg Noodles Prepared For Hungarian Goulash Storage Evaluation

Egg Noodles - 5 min. Boiled	%	Grams
Solids	26.3	652.0
Moisture (Cenco)	63.7	1828.0
	100.0	2480.0

Equilibration Solution For Partially Cooked Egg Noodles	%	Grams
Glycerol	46.6	2380.8
Water	46.5	2373.4
Sodium Chloride	6.3	322.4
Potassium Sorbate	0.6	29.8
	100.0	5106.4

Moisture (v-o) = 48.0%
Aw = 0.84

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table XIII

Formula #6068-22 For Beef Pieces Prepared For Hungarian Goulash Storage Evaluation

Beef Chunks	%	Grams
Solids	35.0	700.0
Moisture (Cenco)	65.0	1300.0
	100.0	2000.0

Equilibration Solution For Beef Chunks	%	Grams
Water	45.9	1700.0
Glycerol	34.3	1270.0
Beef Soup Base (Good Season's)	13.6	500.0
Sodium Chloride	5.4	200.0
Potassium Sorbate	0.8	30.0
	100.0	3700.0

Moisture (v-o) = 44.5%
Aw = 0.82

Table XIV

Formula #6068-15 For Onion Pieces Prepared For Hungarian Goulash Storage Evaluation

Onion Pieces	%	Grams
Solids	10.9	109.0
Moisture (Handbook)*	89.1	891.0
	100.0	1000.0

Equilibration Solution For Onion Pieces	%	Grams
Water	46.1	1027.0
Glycerol	47.1	1050.0
Sodium Chloride	6.3	140.0
Potassium Chloride	0.5	10.5
	100.0	2227.5

Moisture (v-o) = 58.5%
Aw = 0.85

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8.

Table XV

Formula #6068-35 For Sauce Prepared For Hungarian Goulash
Storage Evaluation

Ingredients	%
Wesson Oil	29.9690
Water	25.7500
Glycerol	15.0000
Fresh Egg Yolk	10.0000
Dri-Fri with .076% Tenox 6 (Drew)	6.0000
Frodex, 15 DE	5.2900
Sodium Chloride	2.7500
Sucrose	2.0015
Beef Soup Base (Good Season's)	0.7500
Paprika	0.7000
Onion Powder	0.5000
Potassium Phosphate	0.4000
Potassium Sorbate	0.3000
Citric Acid	0.2000
Caramel Color (Twitchell)	0.1500
Garlic Powder	0.1000
Beta-Carotene	0.1000
Imitation Tomato Flavor (Givaudan F5515)	0.0210
FD&C Red #2	0.0101
FD&C Yellow #5	0.0066
FD&C Yellow #6	0.0013
FD&C Blue #1	0.0005
	100.0000

Table XVI

Formula #6068-26 For Lamb Pieces Prepared For Irish Stew Storage Evaluation

Lamb Chunks	%	Grams
Solids	27.0	507.6
Moisture (Handbook)*	73.0	1372.4
	100.0	1880.0

Equilibration Solution For Lamb Chunks	%	Grams
Water	47.4	1567.9
Glycerol	44.3	1462.6
Sodium Chloride	7.4	244.4
Potassium Sorbate	0.9	30.1
	100.0	3305.0

Moisture (v-o) = 40.2%
Aw = 0.86

Table XVII

Formula #6068-25 For Potatoes Prepared For Irish Stew Storage Evaluation

Raw Potato Slices	%	Grams
Solids	20.0	500.0
Moisture (Cenco)	80.0	2000.0
	100.0	2500.0

Equilibration Solution For Potato Slices	%	Grams
Water	49.3	2850.0
Glycerol	43.3	2500.0
Sodium Chloride	6.9	400.0
Potassium Sorbate	0.5	30.0
	100.0	5780.0

Moisture (v-o) = 53.1%
Aw = 0.87

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table XVIII

Formula #6068-24 For Onions Prepared For Irish Stew Storage Evaluation

Onions, Small, Frozen, Whole	%	Grams
Solids	11.0	88.0
Moisture (Handbook)*	89.0	712.0
	100.0	800.0

Equilibration Solution For Onions	%	Grams
Glycerol	58.1	866.4
Water	34.3	512.0
Sodium Chloride	6.4	96.0
Potassium Phosphate	0.5	7.2
Potassium Sorbate	0.5	7.2
Citric Acid	0.2	2.4
	100.0	1491.2

Moisture (v-o) = 59.8%
Aw = 0.85

Table XIX

Formula #6068-38 For Gravy Prepared For Irish Stew Storage Evaluation

Ingredients	%
Wesson Oil	32.40
Water	23.50
Glycerol	12.50
Dri-Fri with .076% Tenox 6 (Drew)	6.00
Frodex, 15 DE	5.54
Sucrose	5.00
Fresh Egg Yolk	10.00
Sodium Chloride	3.00
Beef Soup Base (Good Season's)	0.50
Caramel Color (Twitchell)	0.40
Potassium Phosphate	0.40
Potassium Sorbate	0.30
Onion Powder	0.35
Citric Acid	0.10
Imitation Lamb Aroma (Polak's 520014)	0.01
	100.00

Moisture (v-o) = 25.7%
Aw = 0.85

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table XX

Formula #6068-03 For Potatoes Prepared For Improved Beef Stew Storage Evaluation

Raw Potato Slices	%	Grams
Solids	20.0	600.0
Moisture (Cenco)	80.0	2400.0
	100.0	3000.0

Equilibration Solution For Potato Slices	%	Grams
Water	44.1	2475.0
Glycerol	44.1	2475.0
Sodium Chloride	5.6	315.0
Beef Soup Base (Good Season's)	4.7	262.5
Potassium Phosphate	0.7	42.0
Potassium Sorbate	0.6	31.5
Citric Acid	0.2	10.5
	100.0	5611.5

Moisture (v-o) = 49.6%
Aw = 0.84

Table XXI

Formula #6068-02 For Beef Prepared For Improved Beef Stew Storage Evaluation

Beef Pieces, Lean, Trimmed	%	Grams
Solids	35.0	1260.0
Moisture (Handbook)*	65.0	2340.0
	100.0	3600.0

Equilibration Solution For Beef Pieces	%	Grams
Water	45.9	3060.0
Glycerol	34.4	2286.0
Beef Soup Base (Good Season's)	13.5	900.0
Sodium Chloride	5.4	360.0
Potassium Sorbate	0.8	54.0
	100.0	6660.0

Moisture (v-o) = 42.3%
Aw = 0.83

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table XXII

Formula #6068-01 For Gravy Prepared For Improved Beef Stew Storage Evaluation

Ingredients	%
Wesson Oil	30.0
Water	22.9
Glycerol	12.0
Fresh Egg Yolk	10.0
Frodex, 15 DE	6.8
Dri-Fri with .076% Tenox 6 (Drew)	6.0
Sucrose	5.0
Beef Soup Base (Good Season's)	4.0
Sodium Chloride	1.5
Caramel Coloring (Twitchell)	1.0
Beef Flavoring (Corral)	0.5
Potassium Sorbate	0.3
	100.0

Moisture (v-o) = 29.3%
Aw = 0.82

Table XXIII

Formula #6068-12 For Apples Prepared For Improved Apple Pie Filling Storage Evaluation

Apples, Sliced, Blanched	%	Grams
Solids	7.6	760.0
Moisture (Cenco)	92.4	9240.0
	100.0	10000.0

Equilibration Solution For Blanched Apple Slices	%	Grams
Glycerol	41.96	10,074.0
Sucrose	41.96	10,074.0
Water	14.83	3,557.0
$CaCl_2$	0.60	143.9
Potassium Sorbate	0.45	108.0
Ascorbic Acid	0.15	36.0
$Na_2S_2O_3$	0.05	10.8
	100.00	24,003.7

Moisture (v-o) = 44.0%
Aw = 0.85

Table XXIV

Formula #6068-40 For Dry Filling Mix Prepared For Improved Apple Pie Filling Storage Evaluation

Ingredients	%
Sucrose	79.34
Cornstarch	17.05
Malic Acid	1.31
Cinnamon	1.29
Nutmeg	0.65
Sodium Chloride	0.36
	100.00

Table XXV

Formula #6068-09 For Macaroni Prepared For Macaroni and Cheese Storage Evaluation

Macaroni, 8 min. Cooked Elbow	%	Grams
Solids	37.0	2521.00
Moisture (Cenco)	63.0	4292.00
	100.0	6813.00

Equilibration Solution For Partially Cooked Macaroni	%	Grams
Water	48.8	7780.40
Glycerol	42.7	6813.00
Sodium Chloride	8.0	1280.80
Potassium Sorbate	0.5	81.76
	100.0	15955.96

Moisture (v-o) = 46.1%
Aw = 0.83

Table XXVI

Formula #6068-10 For Cheese Prepared For Macaroni and Cheese Storage Evaluation

Ingredients	%
Water	17.70
Spray-Dried Cheddar Cheese (Kraft)	17.57
American Cheese (Grocery Type)	17.57
Dri-Fri with .076% Tenox 6 (Drew)	14.45
Wesson Oil	9.86
Non-Fat Dry Milk Solids	8.61
Glycerol	7.50
Hydrol 100 (Durkee)	3.59
Sodium Chloride	0.57
Beef Soup Base (Good Season's)	0.50
Starch (National, Purity 270)	0.44
Kelcoloid	0.30
Monosodium Glutamate	0.30
Potassium Sorbate	0.30
Citric Acid	0.28
Mustard Powder	0.22
Lecithin	0.17
Cheddar Cheese Flavor (Gen'l Foods, #5577-98)	0.07
	100.00

Moisture (v-o) = 23.0%
Aw = 0.83

Table XXVII

Formula #6068-31 For Pork Prepared For Sweet and Sour Pork Storage Evaluation

Pork Chunks, Raw, Trimmed	%	Grams
Solids	30.0	1428.0
Moisture (Handbook)*	70.0	3332.0
	100.0	4760.0

Equilibration Solution For Pork Pieces	%	Grams
Glycerol	45.6	2952.0
Water	43.2	2800.0
Sodium Chloride	10.5	680.0
Potassium Sorbate	0.7	48.0
	100.0	6480.0

Moisture (v-o) = 41.2%
Aw = 0.81

Table XXVIII

Formula #6068-33 For Pineapple Prepared For Sweet and Sour Pork Storage Evaluation

Pineapple Chunks, Canned, Drained	%	Grams
Solids	27.0	245.0
Moisture (Cenco)	73.0	661.0
	100.0	906.0

Equilibration Solution For Pineapple Pieces	%	Grams
Glycerol	55.0	1089.0
Sucrose	23.0	454.0
Water	21.5	424.0
Potassium Sorbate	0.5	10.0
	100.0	1977.0

Moisture (v-o) = 43.0%
Aw = 0.85

*U.S.D.A. "Composition of Foods", Agriculture Handbook No. 8

Table XXIX

Formula #6068-34 For Celery Prepared For Sweet and Sour Pork Storage Evaluation

Celery Cross Sections, Blanched	%	Grams
Solids	5.3	42.4
Moisture (Cenco)	94.7	757.6
	100.0	800.0

Equilibration Solution For Celery Pieces	%	Grams
Glycerol	68.4	1056.0
Water	25.2	388.8
Sodium Chloride	5.9	91.2
Potassium Sorbate	0.5	7.2
	100.0	1543.2

Moisture (v-o) = 39.6%
Aw = 0.83

Table XXX

Formula #6068-32 For Sauce Prepared For Sweet and Sour Pork Storage Evaluation

Ingredients	%
Glycerol	25.00
Catsup	23.84
Water	15.00
Vinegar	13.50
Sucrose	11.84
Frodex, 15 DE	4.22
Sodium Chloride	2.59
Corn Starch (Argo)	2.30
Monosodium Glutamate	1.15
Potassium Sorbate	0.30
Mustard Powder	0.23
Onion Powder	0.02
Garlic Powder	0.01
	100.00

Moisture (v-o) = 34.9%
Aw (calculated)= 0.85

Table XXXI

Microorganism Counts At Zero Time, One Month and Four Month Storage At 38°C.

Item	Standard Plate			Molds			Yeast		
	0 time	1 mo	4 mo	0 time	1 mo	4 mo	0 time	1 mo	4 mo
Chicken a La King #6003-70	770	400	30	<10	<10	<10	<10	<10	<10
Ham in Cream Sauce #6003-72-3	1700	700	180	<10	<10	<10	<10	<10	<10
Improved Ham in Cream Sauce #6068-43	200	130	100	<10	<10	<10	<10	<10	<10
Tuna in Cream Sauce #5713-98	280	70	100	<10	<10	<10	<10	<10	<10
Hungarian Goulash #6068-14	900	510	500	<10	<10	10	110	<10	10
Irish Stew #6068-23	1000	210	100	<10	<10	<10	<10	<10	<10
Improved Beef Stew #5713-97	20	<10	100	<10	<10	<10	<10	<10	<10
Apples (For Pie Filling) #6068-12	<10	<10	<10	<10	<10	<10	<10	<10	<10
Macaroni #6068-09	70	<10	<10	<10	<10	<10	<10	<10	<10
Cheese #6068-10	250	280	300	10	<10	<10	<10	<10	<10
Sweet and Sour Pork #6068-29	40	<10	10	<10	<10	<10	<10	<10	<10

Table XXXII

Sensory Evaluation Ratings After Four Months' Storage

	Control	0°C	38°C
Chicken a la King (25% H_2O added to IM Samples)	10	6.9	5.1
Improved Ham in Cream Sauce (15% H_2O added to IM Samples)	10	8.9	6.6
Tuna in Cream Sauce (6% H_2O added to IM Samples)	10	8.0	7.1
Hungarian Goulash (15% H_2O added to IM Samples)	10	7.6	6.4
Irish Stew (5% H_2O added to IM Samples)	10	8.9	7.0
Improved Beef Stew (no H_2O added to IM Samples)	10	6.7	5.6
Improved Apple Pie Filling (made as per recipe on page 22)	10	8.8	7.8
Macaroni and Cheese (made as per recipe on page 22)	10	7.4	5.6
Sweet and Sour Pork (20% H_2O added to IM Samples)	10	7.9	6.7

Table XXXIII

Pathogenic Inoculation Study
Counts* During Storage

I. Chicken a la King Casserole

	0-time	1 month	4 months
non-inoculated control			
SPC	770	400	30
inoculated counts			
Staph. aureus	14,000	1,800	.4
E. coli	6,000	<10	<10
Salmonella	7,400	<10	<10
Cl. perfringens	12,000	<10	<10

II. Ham in Cream Sauce Casserole

	0-time	1 month	4 months
non-inoculated control			
SPC	1,700	700	180
inoculated counts			
Staph. aureus	12,000	1,900	.4
E. coli	9,700	<10	<10
Salmonella	6,400	<10	<10
Cl. perfringens	5,700	<10	<10

*All analyzed in triplicate

Table XXXIV

Nutritional Analysis* at Zero Time and Four Month Storage at 38°C

I. Chicken a La King Casserole

	mg/100 grams		
	Thiamine	Riboflavin	Niacin
Zero Time	0.05	0.143	2.10
Four Months (air)	0.03	0.167	1.69
(N_2)	0.03	0.176	1.74
% Difference (air)	-40.0	+16.8	-19.5
(N_2)	-40.0	+23.0	-17.2

II. Ham in Cream Sauce Casserole

	mg/100 grams		
	Thiamine	Riboflavin	Niacin
Zero Time	0.13	0.188	0.79
Four Months (air)	0.07	0.184	0.636
(N_2)	0.07	0.198	0.622
% Difference (air)	-46.0	-2.1	-19.0
(N_2)	-46.0	+5.3	-21.5

III. Apple Slices (For Pie Filling)

	mg/100 grams	
	Ascorbic Acid	Thiamine
Zero Time	80.2	0.03
Four Months	46.8	$<$0.01
% Difference	-41.5%	-66.0%

* Analyses were conducted by the Wisconsin Alumni Research Foundation using the following methods of analysis:

Niacin: A.O.A.C., 771 (1965) 10th Ed.
Riboflavin: A.O.A.C., 773 (1965) 10th Ed.
Thiamine: A.O.A.C., 758 (1965) 10th Ed.
Ascorbic Acid: J. Biol. Chem., 160, 217 (1945)

APPENDIX A

Standard Plate Count Microbiological Method

The method used can be found in the latest edition of "Standard Methods for the Examination of Dairy Products", using Tryptone Glucose Extract agar.

APPENDIX B

Molds and Yeasts Microbiological Method

The method used can be found in the latest edition of "Standard Methods for the Examination of Dairy Products", using Malt agar.

APPENDIX C

Coagulase Positive Staphylococci Microbiological Method

The method used is published as the Baer procedure and can be found in the "Journal of Association of Official Analytical Chemists", and in the latest revision of the "Bacteriological Analytical Manual" (Food and Drug Administration) using Trypticase Soy broth + 10% sodium chloride and Vogel-Johnson agar.

APPENDIX D

Coliform Count and E. Coli Microbiological Method

The method used is an "American Public Health Association" procedure and can be found in "Recommended Methods for the Microbiological Examination of Foods", 2nd edition. Method uses Violet Red Bile agar, Brilliant Green Bile broth (2%), Eosin Methylene Blue agar and Indol Methyl-red, Voges-Proskauer, Simmon's citrate test.

APPENDIX E

Salmonella Microbiological Method

The method used is recommended by the "Association of Official Analytical Chemists" and the "Bacteriological Analytical Manual" -- latest revision (Food and Drug Administration.)

APPENDIX F

Clostridium Perfringens Microbiological Method

The method used is a combination of two methods, one of which is the United States Public Health Service test outlined in "Examination of Foods for Enteropathogenic and Indicator Bacteria" in the "Review of Methodology and Manual of Selected Procedures". The second procedure is published by General Foods Corporation in the Journal of Food Science, Volume 34, No. 2, 1969, pages 212-214.

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13. ABSTRACT

Utilizing the immersion-equilibration procedure developed during the previous Phase I, investigation of this program the following casserole-type products were prepared by combining, in accordance with standard formulations, the respective components, including the sauce, which were separately processed to a water activity between 0.80 and 0.85: chicken a la king, ham in cream sauce, tuna in cream sauce, Hungarian goulash, Irish stew, sweet and sour pork and macaroni and cheese. In addition two items, apple pie filling and beef stew, which failed to pass the storage test of Phase I were reformulated to conform. All named items were rated acceptable after 4 months storage at 38°C except the ham in cream sauce which was found to be rancid.

Samples of chicken a la king and ham in cream sauce were inoculated with Staph. aureus, E. coli, Salmonella, and Cl. perfringens at levels of 6-14,000 organisms per gram. Except for S. aureus viable counts were uniformly less than 10 per gram after one month storage at 38°C. After four months samples inoculated with S. aureus ran 0.4 organism per gram. Observations were performed on the loss of thiamine, riboflavin and niacin during storage for 5 months at 38°C. Thiamine loses amounted to 40-60 percent. niacin around 20 percent, while no loss was observed for riboflavin. Notwithstanding substantial improvements over Phase I in acceptability of all items and components thereof, the depression of water activity as accomplished in Phase II results in a less acceptable flavor.

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Parameters	8					
Moisture	8		9			
Military rations	9		9		9	
Food products	9		9		9	
Stabilization			8			
Preparation					8	
Storage stability					8	
Vitamin content					8,9	